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ABSTRACT

The present experiment tested the hypothesis that learning under conditions of high arousal should lead to stronger permanent memory and weaker immediate memory than learning under conditions of low arousal. When digital vasoconstriction was used as the measure of arousal, the results confirmed the hypothesis. Learning under high and low arousal defined by digital vasoconstriction revealed a significant interaction ($p < .05$) between arousal level and time of recall. At immediate retention, low arousal learning was superior to high arousal learning but at long-term retention this relationship was reversed. However, arousal level as defined by heart rate change, showed no significant interaction with retention. Orienting response level showed a complex interaction with recall interval, sex, and grade ($p < .05$). Although most groups showed classical forgetting over 24 hours, Second Grade Medium Orienting males and Fourth Grade High Orienting males and Medium Orienting females demonstrated marked resistance to forgetting. (Author)

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INDIVIDUAL DIFFERENCES IN THE ORIENTING RESPONSE AND AROUSAL AS FACTORS IN THE SHORT- AND LONG-TERM RETENTION OF CHILDREN IN GRADES K-4

REPORT FROM THE PROJECT ON MOTIVATION AND INDIVIDUAL DIFFERENCES IN LEARNING AND RETENTION

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By Mary E. Manske and Frank H. Farley

Report from the Project on Motivation and Individual Differences in Learning and Retention

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Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
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STATEMENT OF FOCUS

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Technical Report is from the Motivation and Individual Differences in Learning and Retention Project from Program 1. General objectives of the Program are to generate new knowledge about concept learning and cognitive skills, to synthesize existing knowledge, and to develop educational materials suggested by the prior activities. Contributing to these Program objectives, the Learning and Memory Project has the long-term goal of developing a theory of individual differences and motivation. The intermediate objective is to generate new knowledge of the learning and memory processes, particularly their developmental relationship to individual differences and to motivation.

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ABSTRACT

The present experiment investigated the assumptions that (1) individual differences in the orienting response (OR) as measured by heart rate deceleration to a non-signal tone, can be used to predict retention in a pictorial paired-associate task; and (2) that arousal level during learning, as assessed by either heart rate or blood volume changes interacts with short- and long-term memory. Specifically, it tested the hypothesis that learning under conditions of high arousal should lead to stronger permanent memory and weaker immediate memory than learning under conditions of low arousal. When digital vasoconstriction was used as the measure of arousal, the results confirmed the hypothesis.

Learning under high and low arousal defined by digital vasoconstriction revealed a significant interaction ($p < .05$) between arousal level and time of recall. At immediate retention, low arousal learning was superior to high arousal learning but at long-term retention this relationship was reversed. However, arousal level as defined by heart rate change, showed no significant interaction with retention.

Orienting response level showed a complex interaction with recall interval, sex, and grade ($p < .05$). Although most groups showed classical forgetting over 24 hours, Second Grade Medium Orienting males, and Fourth Grade High Orienting males and Medium Orienting females demonstrated marked resistance to forgetting.

I
INTRODUCTION

The orienting response (OR) is usually considered to involve a constellation of physiological processes that is brought about by a change of stimulation in the environment. Some of the indices that have been used to measure this phenomenon are digital vasoconstriction along with cephalic vasodilation (Sokolov, 1963), galvanic skin response (GSR) magnitude (Raskin, 1969), and heart rate deceleration (Chase & Graham, 1967).

A few experiments have investigated the effects of individual differences (IDs) in the OR in relation to conditioning and complex processes. The empirical work has been conducted with adults who have been classified as either "High" or "Low Orientors" on the basis of their physiological responses to a change in stimulation in the environment.

The OR is generally studied from one of two approaches. The first approach stems from the work of Sokolov (1963) and investigates the hypothesis that the occurrence of an OR enhances stimulus reception both within and across sensory modalities. The second area of research involves the relationship of the OR to established areas of behavioristic interest such as conditioning, learning, and reinforcement. It is currently hypothesized that the occurrence of an OR is necessary for the establishment of conditioning. It is also implied that the OR is closely related to the concepts of arousal and reinforcement. In addition to the assumption that the OR is related to learning, Maltzman and Raskin (1965) also assume that there is a wide range of individual differences in the magnitude of the OR that is reliably evoked in different subjects who are receiving the same stimulus conditions. They also hypothesize that the OR is related to the discrimination of such complex stimuli as words, in addition to raising the sensitivity of sensory analyzers.

Raskin (1969) studied the relationship of IDs in the OR and performance in a semantic conditioning and generalization experiment. GSR was used as the conditioned response. The OR was operationally defined as the magnitude of the GSR evoked by the first UCS, a burst of white noise. High and Low Orienting *Ss* were identified on the basis of their GSR magnitude. It was established that High Orientors showed reliably greater conditioning and semantic generalization than Low Orientors.

As the author points out, it is necessary to have different measures of the OR and learning in order to establish any kind of generality about the relationship of the OR to learning.

Other investigators have reported the relationship of IDs in the OR and performance on a paired-associate (PA) learning task. Belloni (1964) classified subjects into High and Low Orientors on the basis of the magnitude of their GSR to a word. The performance measures used were two paired-associate lists, classified as "easy" and "difficult." It was hypothesized that the OR could be viewed as an index of a "discriminative ability" and that High Orientors would learn both lists more quickly. The authors argued that those conceiving of the OR as a measure of drive would predict that High Orientors would do better on the easy list and that Low Orientors would do better on the difficult list. When the results were investigated within each sex, it was found that High OR males learned the difficult task reliably faster than the Low OR males. The authors concluded that the OR was related to discriminative ability and that it could not be viewed as some kind of drive index, since Manifest Anxiety Scores could not be used to predict performance on the paired-associate list.

Nies (1964) used the same PA lists in a similar experiment and categorized subjects into High and Low Orientors on the basis of magnitude of their GSR to a 90 db. noise. Only male subjects were used. The High OR group

was superior to the Low OR group on both lists when response speed was used as a measure of performance. The High OR group also required fewer trials to criterion than the Low OR group on the difficult list.

Maltzman and Mandell (1968) qualify earlier statements about the OR by stating that there is no logical reason that suggests use of only one unitary OR concept. In an experimental situation the OR is a function of multiple factors such as individual differences, instructions, and other states. In addition, they assume there are a variety of OR measures, both physiological and behavioral. The authors reiterate previous conclusions that the OR defined by GSR does not predict the course of digital vasomotor conditioning. However, when GSR and the amount of alpha blocking induced by the first word in a word habituation list were taken as two measures of individual differences in the OR it was found that both indices could predict the amount of semantic conditioning as defined by the opposite response system. Orienting response level, as defined by GSR measures also reliably differentiated the "aware" *S*s from the "unaware" *S*s, i.e., those who could or could not verbally state the contingencies between the CS and the UCS.

There is some evidence, then, that IDs in the OR can be used to predict performance in a highly unrelated situation. A study conducted by Farley and Manske (1970) extended these conclusions in several directions by using *S*s of Kindergarten age with heart rate deceleration to a tone being designated as the measure of the orienting response. Classification of *S*s utilized three OR categories, High, Medium, and Low, as contrasted to previously used High and Low. Results showed a significant sex by OR classification interaction for number of correct responses on a pictorial PA task. The measure of retention was taken immediately after learning. For males, poorest performance was associated with the Medium OR classification; whereas, for females, poorest performance was associated with the Low OR classification.

Since the OR is generally considered as an indicant of arousal state, it is appropriate to consider a group of studies relating arousal and PA learning. These studies have derived theoretical impetus from Hebb's (1949) notion that learning involves a consolidation process based on dual physiological processes, i.e., reverberation of neural circuits comprising the memory trace, followed by organic changes between nerve cells. Under low arousal conditions, relatively little nonspecific neural activity will be available to support the reverberating trace which will result in little consolidation and poor long-term retention. On the other hand, under high arousal conditions, the increased nonspecific neural activity will result in more reverberation and long-term retention will be better. At short-term retention, recall of those items learned under high arousal should be inferior to recall of items learned under low arousal due to unavailability of the memory trace. There are several studies that have supported Hebb's consolidation theory by showing an interaction between arousal level and time of recall. Walker (1958) expanded on Hebb's basic statement and included it in his Action Decrement Theory. "Action decrement" is a term coined by Walker to what otherwise has been known as "reactive inhibition." Any action is considered to be followed by an action decrement, which is a lowered capacity for rearousal of the same event. The action decrement is a direct manifestation of the process of perseverative consolidation which is necessary for retention and subsequent performance. The action decrement persists for a limited amount of time and then dissipates. Under many circumstances the dissipation of the action decrement is followed by an action increment which is learning or habit strength. It is also hypothesized that the greater the decrement, the quicker the recovery and the greater the eventual increment of learning. The model was originally proposed to explain alternation behavior of a rat in a T-maze, but has been more specifically stated (Walker & Tarte, 1963) to predict behavior in the verbal learning situation as follows: (1) The occurrence of any psychological event, such as an effort to learn an item of a PA list, sets up an active, perseverative trace process which persists for a considerable period of time; (2) The perseverative process has two important characteristics: (a) permanent memory is laid down during this phase in a gradual fashion, and (b) during the active period there is a degree of temporary inhibition of recall, i.e., action decrement (This negative bias against repetition serves to protect the consolidating trace against disruption.); and (3) High arousal during the associative process will result in greater temporary inhibition against recall. Although Walker began theorizing in this general area in 1958, the first actual studies in this area using the PA method were done by Kleinsmith and Kaplan (1963) and Walker and Tarte (1963). As both these studies are rather alike, the first mentioned will be considered

here. To test the predictions, six groups of *S*s were given a single learning trial with a list of 8 word-number paired-associates. The different groups were then tested for recall at intervals of 2 minutes, 20 minutes, 45 minutes, 1 day, and 1 week. The eight stimulus words were expected to produce different arousal levels. They were: KISS, RAPE, VOMIT, EXAM, DANCE, MONEY, LOVE, SWIM. The response items were single digits from 2 to 9. During the training trial, *S* saw the items projected on a screen in this manner. First, the stimulus was presented alone for 4 seconds. Then the stimulus and response were presented together for 4 seconds. Then two slides with four colors on them were each projected for 4 seconds. The color naming task was used to separate the arousal effects from one slide to the next. Instructions to *S* for the whole task were to "concentrate carefully on both colors and word-number pairs" as *S* called them out loud. Subject was *not* specifically told that he would be tested for recall. During the recall session *S* was instructed to indicate the correct number for each stimulus word as it appeared. Colors were again used as an interpolated task.

Skin resistance was used as the measure of arousal and was recorded during learning. Any drop in *S*'s skin resistance which occurred within 4 seconds of presentation of a given word was considered an arousal deflection. Each of the *S*s 8 GSR deflections were then ranked. The three highest deflections for *each S* were designated as "high arousal learning" and the three lowest deflections for each *S* were designated as "low arousal learning." To assure constancy of conditions, electrodes and recording apparatus were also used during the recall session. It should be emphasized that the data analysis was not performed as a function of *a priori* experimental arousal conditions but that the independent variable was high vs. low arousal as measured by GSR deflection during the experiment. It should also be noted that two items for each *S* were left out in the analysis.

The results clearly show the predicted relationship between high and low arousal recall as a function of time. Analysis of variance of correct responses showed a significant interaction of arousal condition and time. At immediate recall, numbers associated with low arousal words were remembered significantly more than numbers associated with high arousal words. The capacity to recall numbers associated with low arousal words decreased as a function of time in a normal forgetting pattern. However, numbers associated with high arousal words were recalled significantly better than numbers associated with low arousal words at 45 minutes. This relationship continued through both the 1 day and the 1 week conditions. The high arousal words clearly demonstrated a reminiscence effect. On the basis of these differential forgetting results, the authors concluded that the hypothesis of reverberating neural circuits being activated during the consolidation process was supported.

One of the criticisms of the Kleinsmith and Kaplan (1963) study is that *words* were used to vary the level of arousal. These words may have differed on some dimension other than arousal, such as meaningfulness or frequency. However, this other dimension would have to correlate with GSR, since this is what actually is being used to indicate arousal. Also, there is little suggestion in the literature that these other dimensions would lead to a prediction of differential forgetting. However, Kleinsmith and Kaplan (1964) attempted to test the independence of the arousal phenomenon from the association value or other qualities unique to the individual stimuli. Nonsense syllables of zero association value were used as the stimuli and single digit numbers from 2 to 7 were used as the response items. It was expected that the arousal qualities of the stimuli would be such that the high and low arousal curves would contain essentially the same items, since no nonsense syllable would be expected to be consistently high arousing or low arousing, by virtue of its being nonsense. The *S*s were given a single learning trial with a six-item PA list. Color naming was again used as an interpolated task. Presentation rate and instructions were the same as in the 1963 study. As before, any drop in *S*'s skin resistance level which occurred within 4 seconds of presentation of the nonsense syllable was considered an arousal deflection. Each of the *S*'s six GSR deflections were then ranked. The three highest deflections for each *S* were then labeled "high arousal learning" and the three lowest GSR deflections were labeled "low arousal learning." The three groups were tested at recall intervals of 2 minutes, 20 minutes, and 1 week.

The analysis of variance of correct responses showed a significant interaction between arousal condition and recall interval. At immediate recall (2 minutes) numbers associated with low arousal nonsense syllables were recalled significantly more than numbers associated with high arousal nonsense syllables. After 1 week, the situation was reversed, and numbers associated with high

arousal learning were recalled significantly better than numbers associated with low arousal learning.

Maltzman, Kantor, and Langdon (1966) questioned the theoretical generality of the previous studies for two reasons. First, the effects of arousal during learning and retention were confounded, since the stimulus words were presented as cues in the retention test as well as in the single learning trial. Second, physiological data are accumulating which indicate that the concept of nonspecific arousal based on the activity of the brain stem reticular activating system is greatly oversimplified. The authors suggest that the GSR measures are correlates of the orienting reaction and not of the consolidation process. In order to remove the external arousal stimulus from the recall session, a one-trial, free-learning task was used rather than the PA task. The Walker and Tarte (1963) high and low arousal words were used in two counterbalanced lists of 16 words each.

Palmar GSR and cephalic vasomotor activity were recorded during learning and used as the measures of the OR. The results showed that retention was better for high arousal words at both the 2-minute and 30-minute intervals.

The authors conclude that the lack of interaction between retention interval and type of word is a contradiction for Walker's action decrement hypothesis. They argue that the GSR is not a measure of the neural activity during the consolidation process but that it is a measure of the orienting response. Sokolov (1963) has found that the occurrence of an OR facilitates the reception of stimulation. It has been shown to increase the sensitivity of sensory analyzers, receptors, and their peripheral and central nervous system components. The authors extend this analysis, and assume that the OR is related to the discrimination of complex stimuli such as words, as well as to the sensitivity of sensory analyzers. This increased discrimination should facilitate learning. In a sense what is being said is that the GSR is measuring some attentional process, and whatever is being paid attention to will be better learned, and thus remembered.

In a reply to the above study, Kaplan and Kaplan (1968) noted that in the reanalysis of their previous data recall performance was predicted only by GSRs during learning and not by GSRs given during recall. The authors also noted several procedural changes in the Maltzman, Kantor, and Langdon study.

First, the longest retention interval used was only 30 minutes as contrasted to the previous studies that used 24-hour or 1-week retention. Perhaps the consolidation process is still going on at this point in time and the memory trace is still relatively unavailable. The second criticism concerns the use of the *a priori* designated high and low arousal lists. Although the GSR was correlated with the designated level of arousal, it was not perfectly correlated. Thus, the data analysis is not as precise as it could be if it were performed on the basis of measured arousal rather than assumed arousal. When this *a priori* designation of arousal conditions is used it now becomes important to control the two groups of words on such dimensions as frequency, meaningfulness, and other characteristics of words that may influence learning. The superior retention of high arousal words may be related to one of these dimensions, and if this is so, these results could easily be predicted on that basis. Another criticism of this study is the use of a 10-second interword interval without the use of an interpolated task. Differential rehearsal of high and low arousal words may very well be taking place. The criticism that high arousal words are more easily categorized is also relevant here, since this may facilitate retention.

Farley (1969a) also employed a free learning paradigm in order to eliminate the overt presence of the arousal stimulus during recall and tested retention on the Walker and Tarte (1963) word list either immediately or after 3 days. Context of list was varied to include (1) high-arousal words only, (2) low-arousal words only, and (3) half high- and half low-arousal words. When considering the results from this last condition, which is similar to the Maltzman, Kantor, and Langdon (1966) procedure, the results are similar to Maltzman, *et al.*, in which high-arousal words were recalled better at both immediate and 3-day retention intervals. However, data from the homogeneous lists showed that high-arousal words were recalled better only at the 3-day retention interval and not at the immediate retention interval. These results suggested that the findings of Maltzman, *et al.*, may have been due to their mixed-list design.

Uehling and Sprinkle (1968) also suggested that arousal during recall may be responsible for retention differences and proceeded to manipulate arousal 3 minutes prior to recall by the introduction of irregular intervals of white noise at 80 db. The retention interval was also varied to include (a) immediate recall, (b) 24-hour recall, and (c) 1-week

recall. At immediate retention there was no difference in recall due to the white noise manipulation, but at the 24-hour and 1-week recall intervals, the group given white noise showed significantly better recall than those receiving no white noise. The authors suggest that the data be interpreted by an arousal framework that expects facilitated performance when there is sensory input to the brain stem reticular formation, but only when that performance is not near optimum, i.e., at the 24-hour and 1-week recall intervals. These results tend to question previous uses of consolidation theory to explain superior long-term recall for high arousal learning since the same stimulus items are present at both learning and recall. However, even if arousal is present at recall and is facilitating to it, the suppression of recall that is frequently obtained at immediate retention under high arousal conditions is not expected. In addition, facilitation of long-term retention by arousal at recall does not conflict with results predicted by consolidation theory. Both effects can be operative without conflict.

Levonian (1966) recorded GSR during presentation of a traffic safety film and found that retention items (recalled both at immediate retention and 1 week later) showed a larger resistance decrement in the 30 seconds preceding information presentation than in the 30 seconds following. However, items that were reminisced (forgotten at immediate retention but recalled at 1-week retention) showed a larger resistance decrement following information presentation than preceding it. The author hypothesizes that a GSR which precedes information is really an orienting response that enhances perceptual sensitivity, thus facilitating the reception and retention of information. However, a GSR that follows information will inhibit short-term, but facilitate long-term, retention according to the mechanisms proposed by consolidation theory.

Kaplan, Kaplan, and Sampson (1968) measured GSR to items presented either as pictures or as words. Free recall was tested at immediate and 30-minute retention intervals for all *S*s. The mean GSR for reminisced items (forgotten at immediate retention but recalled at 30-minute retention) was significantly greater than the mean GSR for forgotten items (remembered at immediate retention but forgotten at 30-minute retention). They also found that GSR levels (High, Medium, or Low) during learning predicted recall of both picture and word items when the GSR used was that given to items as words. Better recall was associated with higher levels of GSR. This relationship did not hold when the GSR used was that given to items as pictures.

Other studies (Farley, 1969b; Lovejoy & Farley, 1969; and Levonian, 1967) have continued to reveal an interaction between arousal level and time of recall. Learning under conditions of low arousal has demonstrated a typical forgetting curve where immediate recall is good but retention decreases rapidly over time. High arousal learning, on the other hand, has demonstrated reminiscence or a marked resistance to forgetting over time.

It is the purpose of the present study to combine the two areas involving the orienting response and arousal and relate them to short- and long-term retention. This experiment will follow up that of Farley and Manske (1970) by studying short-term PA recall as a function of sex and IDs in the OR measured by heart rate deceleration, but will extend it to include a long-term retention condition, continuous arousal measurement during learning, and a developmental comparison from K-4. Specifically, number correct on an eight-item, one-trial, pictorial PA task will be analyzed as a function of OR classification (high vs. medium vs. low), level of arousal during learning (high vs. low), sex, and time of retention test (immediate vs. 24-hour). The orienting response will be measured behaviorally by the use of heart rate deceleration. Graham and Clifton (1966) and Chase and Graham (1967) have provided support of the hypothesis that heart rate deceleration is a major component of the OR. Arousal level during learning will be assessed by two measures, heart rate deceleration and finger pulse volume, which can be used as an indirect measure of digital vasoconstriction. The use of heart rate deceleration rather than acceleration has been suggested by Lacey's (1959) concept of the "directional fractionation of response." He proposes that there are instances in which the direction of change in one physiological variable is contrary to what is expected normally as an activation response. For example, Lacey (1963) showed there are occasions such as those in which *S*s had to pay attention to visual and auditory stimuli when heart rate decelerated but skin conductance increased. However, heart rate accelerated and skin conductance increased when *S*s had to solve arithmetic problems or mentally concentrate. In the present study the *S* has to attend to visual and auditory stimuli in order to learn. The measurement of heart rate deceleration will be taken in the first 5 seconds of stimulus-response presentation before *E* names the

objects to be associated. Since the emphasis of the task is on "environmental intake" cardiac deceleration was considered the appropriate arousal measure. The use of digital vasoconstriction was one of the measures of the orienting response originally proposed by Sokolov (1963) although he usually measured cephalic vasodilation concurrently.

Heart rate change information is being used to assess both the orienting response and arousal level during learning. However, in one instance, the response that is measured is evoked by a stimulus that is a non-signal tone, and, in the second instance the response that is measured is evoked by stimulus pictures. This second measure can be considered as representative of a transient process, the response changing from stimulus to stimulus. Since the analysis of high- and low-arousal learning is considered within each subject, the designation of arousal condition is peculiar to that particular subject and does not depend on some absolute level of arousal. On the other hand, the pretest OR measure considers the magnitude of *S*'s response, compares it with the rest of the sample, and classifies him accordingly. In addition, arousal level during learning will be assessed by vasomotor activity. It is hoped to predict short-term and long-term retention by the use of these two variables, OR classification and arousal level during learning. On the basis of consolidation theory, it is predicted that items learned under high arousal will show relatively poor short-term retention as compared to items learned under low arousal. On the other hand, at long-term retention, items learned under high arousal will show marked resistance to forgetting as compared to items learned under low arousal. Statistically, an interaction between arousal condition and retention interval is predicted.

The relation of the OR and retention is also of interest and depending on one's conception of the OR, predictions will vary. If one views the OR as an index of discriminative ability, then one might predict only a main effect of OR, with High Orientors performing better than Medium or Low Orientors at both retention intervals.

Although previous work by Maltzman and associates with adults has tended to support this prediction, research by Farley and Manske (1970) with children has not. The latter authors have found that the relationship of IDs in the OR to retention is non-monotonic and a function of sex using a short-term retention test in PA learning.

If one views the OR as an overall arousal measure, on the basis of consolidation theory an interaction between OR level and short- and long-term retention would be predicted. At short-term retention, High Orientors would be expected to display poorer retention than Low Orientors, but at long-term retention this relationship should be reversed. It has been proposed by several investigators (Duffy, 1962; Hebb, 1949; Berry, 1962) that there is an inverted U-shaped function between arousal and performance and that a middle level of arousal is optimal for learning. Kleinsmith, Kaplan, and Tarte (1963) showed that in a free recall learning situation skin conductance level was related to recall in an inverted-U manner at immediate retention (6 minutes). However, at the 1-week recall interval, skin conductance was related to recall in a linear manner with greater conductance levels being associated with better recall.

Another interesting comparison will be that of the interaction between OR level, arousal condition, and retention. A question to be considered is the effect of level of arousal during learning for each OR group. Is high arousal learning better for a High Orientor as opposed to a Medium or a Low Orientor? If the OR is viewed as an activation concept it would be expected that high arousal for a High Orientor would have a deleterious effect on short-term retention, but would facilitate long-term retention. Admittedly, there is not enough known in this area or adequate theoretical structure to make precise predictions about this particular interaction.

II
METHOD

SUBJECTS

The *S*s used in this study were 314 students from the Kindergarten and Second and Fourth Grades of the Glendale School in Madison, Wisconsin. In the Kindergarten class, 52 of the *S*s were males and 47 were females. In the Second Grade class, 58 of the *S*s were males and 50 were females, and in the Fourth Grade class, 46 of the *S*s were males and 61 of the *S*s were females. All of these *S*s were given the pretest session in order to determine the magnitude of their orienting response. Within each grade a distribution of these magnitudes was made and divided into thirds, *S*s being designated as either High, Medium, or Low Orientors. 288 *S*s were randomly selected within each grade by orienting response by sex category to participate in the second part of the study carrying out the original plan of using eight *S*s in each orienting response by sex by grade by retention interval cell. This was not always possible since there was an unequal distribution of males and females within each grade and within each orienting response classification. A variety of other problems also occurred which caused either the loss or replacement of *S*s. Two Kindergarten females and one male refused to participate in the second part of the study. One Kindergarten female and one Fourth Grade female were absent for their 24-hour retest. Five *S*s had unreadable heart rate records. Two of these *S*s were replaced by *S*s of their same OR by grade by sex category, and the other three *S*s could not be replaced because of lack of extra *S*s of their particular classification.

Seven of the *S*s considered in the heart rate analysis did not have blood volume records due to equipment failure. Thus, when considering the analysis that uses heart rate data as the bases for designating high and low arousal learning, 281 *S*s are included in the study, whereas, when considering the analysis that uses blood volume to differentiate high and low arousal learning, 274 *S*s are included.

Testing Sessions

All of the *S*s were involved in at least two testing sessions. Half of the *S*s were brought back for a third session. The first session involved the testing of *S*'s orienting response. The second session, which took place approximately 4 weeks after the first session, involved presentation of a single modified PA learning trial to the *S*. Half of the *S*s received an immediate recall test and the other half received the recall test approximately 24 hours later.

TESTING OF THE ORIENTING RESPONSE

Apparatus and Materials

A Gilson Model M5P polygraph was used to record ECG information. A right-arm-to-left-leg electrode placement was used with the ground electrode attached to the left arm.

In order to elicit the orienting response, a tone of 1000 cycles per second was generated by a Beltone Model Audiometer and delivered via an Electro-Voice Sonocaster loudspeaker. The tone was measured at 61 dbs. by a Stoelting noise level meter. Continuous white noise was delivered free-field for masking purposes by use of a Grayson-Stadler Model 901B white noise generator. The noise level in the testing room from the white noise and the polygraph combined was 58 db.

The *S* sat in a comfortable reclining arm-

chair, resting his left arm on the arm of the chair and his right arm on a pillow placed between him and the right arm of the chair. The room was illuminated by a 60 watt bulb.

Procedure

The *S* was brought into the testing room either by the *E*, or in most cases, by the *S* who had just completed the testing session. After the *S* was seated in the chair, the *E* issued the following instructions:

> Today I would like to learn some things about different sounds and I would like you to help me. Your job is very easy. All I would like you to do is sit very quietly in this chair and listen carefully to some sounds that my machine will make. Do you think you can do that? Good! I know that you can. I'm going to put these three little plates on your arms and one on your legs. Then I'm going to put these clips on. The red one goes here, and the other red one goes here, and the black one goes here. Do they feel okay? Fine. Now I will turn on a machine that will make some soft sounds. For a little while my other machine will make some other sounds that I want you to listen to very carefully. It's very important that you sit very still, without moving any part of your body, while you are listening. Now I will turn off one of the lights, shut the door, and go over to my machine. I will always be in the room with you, but you will not be able to see me because I will be standing behind your chair. Do you remember what your job is? Fine. You must sit quietly and listen to the short sounds that will go on and off starting in a little while. Let's start now.

Resting measures were taken continuously for 3 minutes before delivery of the tone. The white noise was delivered continuously during this period. The 1000 cps tone was presented for a duration of 5 seconds by manually pressing a lever on the audiometer. The *E* was standing at the polygraph which was placed behind the *S*. The *E*'s movements were kept to a minimum in order that they not be a signal to the occurrence of a future event. There was no communication between *E* and *S* except in the case where it was noted that the *S* moved excessively. If this occurred the *E* would remind the *S* to "please sit still."

Testing was carried on throughout the school day which began at 8:30 a.m. and continued until 3:15 p.m.

Data Analyses

The *S*'s heartrate response to the first tone in a series of tones was used as the measure of the OR.

The method for scoring the OR contrasted the lowest beat in the 3 seconds preceding stimulus onset with the lowest beat in the 3 seconds following stimulus onset. These change scores were ordered on the basis of magnitude and the resultant distribution was divided into thirds. The highest deceleration scores occupied the top third of the distribution and *S*s falling into this third were labeled as High Orientors. Medium and Low Orientors were, respectively, those *S*s that fell into the middle and bottom thirds of the distribution. This method of data analysis and the conditions of OR testing were the same as those of Farley and Manske (1970).

LEARNING SESSION

Procedure

The *S*s were given a single learning trial with a list of eight pairs of pictures that served as the stimuli and responses. The pictures were simple black line drawings of things that were familiar to the very youngest of the children in the study. Specifically, the pairs used were:

Baby - Desk	Telephone - Indian
Lamp - Box	Pig - Wagon
Boat - Window	Ball - Ladder
Flag - Wheel	Whistle - Fish

The pairs were presented one at a time via a Kodak Carousel slide projector. Each pair was presented for a duration of 15 seconds. Eight different slide sequences that balanced for ordinal position were used. Sequences were randomly assigned to the *S*s. The projector was located in a room adjacent to the testing room and the slides were projected through a one-way window onto a white opaque screen on the wall in front of the *S*. The noise from the projector could not be heard in the testing room. The *S* was brought

to the testing room either by the *E* or alone upon request by the *S* who had just completed the learning session. Electrodes were again attached to the arms and legs as in the Orienting Response Test session and a finger photo-electric plethysmograph, Gilson Model FP-6, was attached to the index finger on the right hand.

The *S* was instructed to try to remember "what goes together" and was given an example pair that was not tested in later recall. The *S* was not told that he would receive a retention test. When it was clear that the *S* understood the nature of the problem, the learning session was begun. One minute of resting measures was taken before presentation of the first slide. For the first 5 seconds of stimulus-response presentation, the *E* remained silent. Then *E* proceeded to name for the *S* the pictures currently being shown in the following manner:

"That is a _____."
(name of stimulus)

"That is a _____."
(name of response)

"The _____ goes with the
(name of stimulus)
_____."
(name of response)

This procedure was repeated for each stimulus-response pair.

The *S*s were randomly assigned within each orienting response by sex by grade classification to one of two recall conditions. Half of the *S*s in each cell were tested immediately after the presentation of the last stimulus-response item. The other half of the *S*s were tested approximately 24 hours later.

Recall was assessed by use of a matching procedure. The stimulus items were presented to the *S* by use of 2" x 2" cards, with one item on a card. Response items were also placed on identical cards. Both sets of pictures were placed on a board in front of the *S* and he was instructed to match the response item with the appropriate stimulus item. The *E* pointed to the stimulus item and asked the *S* to verbally tell her which was the correct response item. The *E* then placed the designated response item next to the stimulus and proceeded to point to the next stimulus item until all items were matched either correctly or incorrectly. The *S* was instructed that he could change his answer at any time. The order of recall was random and an unlimited amount of time was allowed.

Data Analyses

Physiological measures were also taken during learning and during recall in order to assess high- and low-arousal learning items for each *S*. Continuous records of heart rate and finger blood volume were taken. The physiological data for each *S* were quantified as follows: Any drop in the *S*'s heart rate which occurred within 5 seconds of presentation of the stimulus was considered an arousal deflection. Each of the *S*'s eight deflections were then ranked on the basis of magnitude. The four largest deflections were designated as high arousal learning and the four lowest deflections were designated as low arousal learning. In case of ties, a deflection occurring at a lower level of absolute heart rate was considered higher arousal than a similar deflection occurring at a higher absolute level.

The magnitude of blood volume changes were also assessed in the following way: Any drop in blood volume occurring within 5 seconds of the stimulus-response presentation was considered a vasoconstrictive response. The responses were then scored for the amount of relative change and each of the *S*'s eight responses was then ranked on the basis of its change score. The four items associated with the largest vasoconstrictive responses were designated as high arousal learning items and the four items associated with the smallest vasoconstrictive responses were designated as low arousal learning items.

In the learning task, the recall score was the total number of correct responses provided during the recall test.

III
RESULTS

OR DISTRIBUTION

The mean heart rate change score for High Orientors was -8.80, for Medium Orientors was -2.00, and for Low Orientors was +2.74. The analysis of variance resulted in a significant effect of OR classification, $F(2,263) = 224.9$; $p < .0001$. The complete analysis of variance table for heart rate level and heart rate change scores, and a table of the cell means, are available from the authors.

The overall correlation between heart rate level and heart rate change was -.42, $p < .01$, reflecting the relationship that as heart rate level increases, heart rate change scores decrease in the direction of larger minus or decelerative scores. Considered within each grade separately, the correlation of heart rate level and heart rate change was -.08 in Kindergarten, -.27 in Grade Two, and .11 in Grade Four. Change scores were adjusted by the covariance analysis recommended by Benjamin (1963) in order to remove this correlation from the change scores within each grade. Resultant residual scores were used in order to assign *S*s to respective OR classifications.

ANALYSIS OF VARIANCE ON CORRECT RECALL

The data from the least-squares analysis of variance when arousal is assessed by heart rate deceleration occurring in the first five seconds of stimulus-response presentation are summarized in Tables 1 and 2. The results showed significant main effects of retention, $F(1,245) = 41.69$; $p < .0001$, and grade, $F(2,245) = 3.56$; $p < .03$. Mean correct recall at short-term retention was 4.43 (55%) and at long-term retention was 2.81 (35%). Mean correct recall was 4.03 (50%) for Grade Four, 3.54 (44%) for Grade Two, and 3.29 (41%) for Kindergarten. However, the results involving main effects must be qualified since there was a significant interaction between OR level, sex, retention, and grade, $F(4,245) = 2.88$; $p < .02$. Cell means for this interaction are reported in Table 3. When subsequent analyses were performed separately within each grade level, the interaction was significant only in Grade Two, $F(2,83) = 3.45$; $p < .05$, and approached significance in Grade Four $F(2,83) = 2.84$; $p < .06$.

The interaction between OR level, sex, and retention is shown graphically in Figure 1 for Grade Two data and in Figure 2 for Grade Four data. As may be seen, the interaction is very complex even when considered within each grade level. The differences appear to be strongly associated with the short-term retention condition and minimized at the long-term retention condition. In addition, the amount of forgetting displayed by the groups over 24 hours varies depending on sex and OR level. In Grade Four, Medium Orienting females showed no forgetting over 24 hours and High Orienting males showed little forgetting relative to other groups. In Grade Two, Medium Orienting males showed no forgetting over 24 hours. However, the groups just cited also obtained the lowest recall scores at immediate retention.

The predicted arousal and retention interaction was not significant, $F(1,245) = 1.38$; $p < .24$, although the means did fall in the predicted direction (see Figure 3).

The only other significant interaction was that of arousal level and grade, $F(2,245) = 3.51$; $p < .03$. As may be seen in Figure 4, arousal level acted differentially on recall, dependent on grade levels. Mean correct recall for Grade Four under high arousal conditions was 2.00 (25%) and under low arousal conditions was 2.03 (25%). Mean correct

Table 1. A Summary of Analysis of Variance on Total Recall Scores for Between Sources of Variance (OR, Sex, Retention Interval, and Grade)

Source	*df*	*MS*	*F*	*p* <
(OR)	2	7.77	1.78	.17
(Sex)	1	.53	.12	.73
(Retention)	1	181.69	41.69	.0001
(Grade)	2	15.51	3.56	.03
(OR x Sex)	2	3.23	.74	.48
(OR x Retention)	2	6.30	1.45	.24
(OR x Grade)	4	4.63	1.06	.38
(Sex x Retention)	1	.23	.05	.82
(Sex x Grade)	2	1.48	.34	.71
(Retention x Grade)	2	.16	.04	.96
(OR x Sex x Retention)	2	1.43	.33	.72
(OR x Sex x Grade)	4	2.15	.49	.74
(OR x Retention x Grade)	4	2.40	.55	.70
(Sex x Retention x Grade)	2	.54	.12	.88
(OR x Sex x Retention x Grade)	4	12.56	2.88	.02
Error	245	4.36		

Table 2. A Summary of Analysis of Variance on Total Recall Scores for Within Sources of Variance - HR

Source	*df*	*MS*	*F*	*p* <
(Arous)	1	.00	.00	1.0
(Arous x OR)	2	1.82	1.18	.31
(Arous x Sex)	1	.28	.18	.67
(Arous x Retention)	1	2.13	1.38	.24
(Arous x Grade)	2	5.43	3.51	.03
(Arous x OR x Sex)	2	.76	.49	.61
(Arous x OR x Retention)	2	.73	.47	.63
(Arous x OR x Grade)	2	1.26	.81	.52
(Arous x Sex x Retention)	1	.34	.22	.64
(Arous x Sex x Grade)	2	.48	.31	.73
(Arous x Retention x Grade)	2	.50	.32	.72
(Arous x OR x Sex x Retention)	2	.03	.02	.98
(Arous x OR x Sex x Grade)	4	.61	.39	.81
(Arous x OR x Retention x Grade)	4	2.46	1.59	.18
(Arous x Sex x Retention x Grade)	2	1.11	.72	.49
(Arous x OR x Sex x Retention x Grade)	4	.32	.21	.93
Error	245	1.55		

Table 3. Mean Number Correct Recall for Each OR x Sex x Retention Interval x Grade Cell[1]

Retention Interval	High OR		Medium OR		Low OR	
	Male	Female	Male	Female	Male	Female
			Kindergarten			
Immediate	3.50 (8) (44%)	2.67 (6) (33%)	4.30 (10) (54%)	4.38 (8) (55%)	4.22 (9) (53%)	5.00 (9) (62%)
24-Hour	2.63 (8) (33%)	2.38 (8) (30%)	2.29 (7) (29%)	2.67 (6) (33%)	2.33 (6) (29%)	2.25 (8) (28%)
			Grade 2			
Immediate	6.00 (6) (75%)	3.67 (9) (46%)	3.12 (8) (39%)	5.12 (8) (64%)	4.27 (11) (53%)	4.80 (5) (60%)
24-Hour	2.90 (10) (36%)	2.86 (7) (36%)	3.38 (8) (42%)	2.14 (7) (27%)	2.43 (7) (30%)	2.44 (9) (30%)
			Grade 4			
Immediate	3.43 (7) (43%)	5.00 (7) (62%)	5.29 (7) (66%)	3.89 (9) (49%)	5.29 (7) (66%)	6.22 (9) (78%)
24-Hour	2.90 (10) (36%)	2.62 (8) (33%)	2.60 (5) (32%)	4.00 (10) (50%)	3.29 (7) (41%)	3.67 (9) (46%)

[1]N is given in parentheses. % correct is given in parentheses.

recall in Grade Two was 1.89 (24%) under high-arousal conditions and 1.64 (21%) under low-arousal conditions. In Kindergarten, mean recall under high-arousal conditions was 1.53 (19%) and under low-arousal conditions was 1.76 (22%). The differences between high- and low-arousal learning approached significance in Kindergarten and Grade Two, $F(1, 79) = 3.68$; $p < .06$, and $F(1, 83) = 3.78$; $p < .06$, respectively.

A similar analysis to the above was undertaken using blood volume digital vasoconstriction to define arousal level. Within each *S*, the four largest responses of digital vasoconstriction in the 5 seconds following stimulus-response presentation in the eight-item list were designated as high-arousal learning and the four lowest were designated as low-arousal learning. The complete analysis of variance for the blood volume method of arousal assessment is summarized in Table 4. As may be seen in Figure 5, the correct recall for items learned under the high-arousal blood volume condition was 2.01 (26%) for short-term retention and 1.49 (19% for long-term retention. Mean correct recall for items learned under low-blood volume arousal was 2.33 (29%) for short-term retention and 1.32 (17%) for long-term retention. This predicted arousal and retention interaction was significant, $F(1,238) = 5.90$; $p < .02$.

Subsequent *t* tests showed that the interaction effect was primarily attributable to the differential effect of arousal condition at short-term retention ($t = 2.13$; $df = 2, 38$; $p < .05$). The difference between high- and low-arousal recall at long-term retention was not significant.

The blood volume method of arousal assessment also yielded a significant arousal by sex interaction, $F(1, 238) = 4.76$; $p < .03$. Mean correct recall under high-arousal learning conditions for males was 1.64 (20%), and for females was 1.84 (23%). Mean correct recall under low-arousal learning conditions was 1.84 (23%) for males and 1.70 (21%) for females. This interaction effect which is shown in Figure 6, could not be attributed to significant differences at the .05 level between pairwise comparisons. No other main effects or interactions due to arousal assessed by blood volume response were significant.

Mean correct recall as a function of serial position and short- and long-term recall is plotted in Figure 7. It may be seen that at short-term recall there was a slight primacy effect associated with only the first item and at long-term recall there was a more marked primacy effect associated with the first three items.

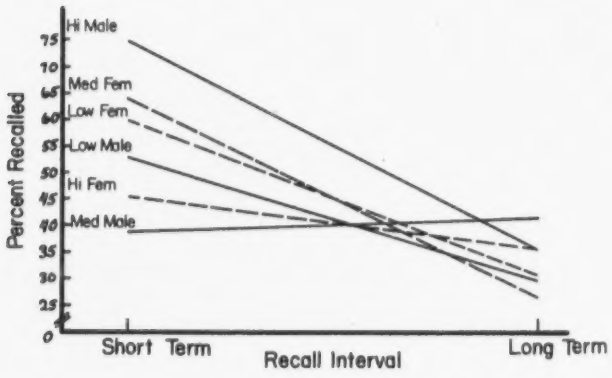

Figure 1. Per Cent Recalled for Grade Two Data as a Function of OR Level, Sex and Recall Interval

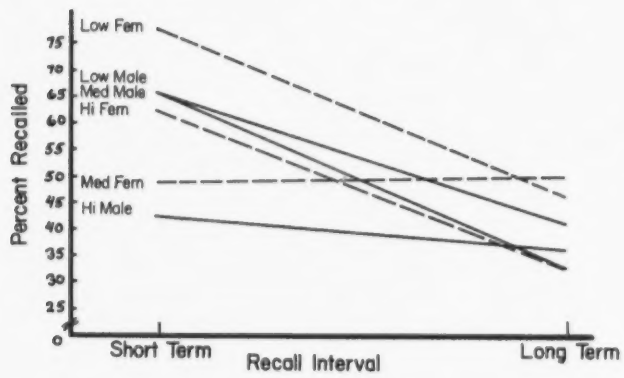

Figure 2. Per Cent Recalled for Grade Four Data as a Function of OR Level, Sex, and Recall Interval

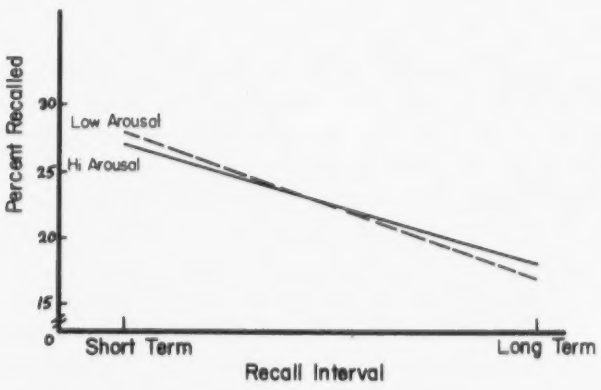

Figure 3. Differential Recall of High and Low Heart Rate Arousal Items at Short- and Long-Term Retention

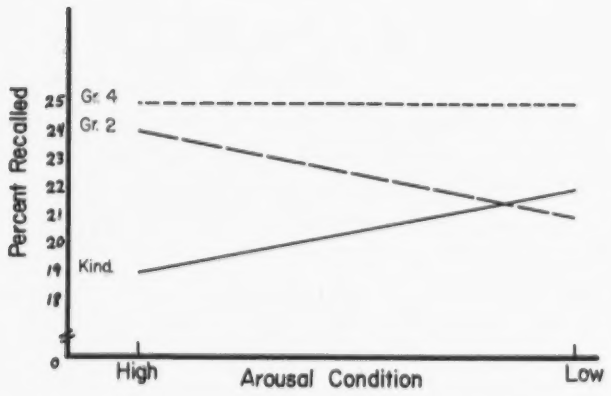

Figure 4. Differential Recall at High and Low Heart Rate Arousal Items as a Function of Grade Level

RELATIONSHIP OF WORDS, ORDINAL POSITION, AND AROUSAL LEVELS

Other experimenters (Walker & Tarte, 1963; Lovejoy & Farley, 1969) have suggested that with GSR data serial position is related to the amount of arousal displayed. Namely, Item One was found to contribute unduly to high arousal and therefore, subsequent analyses were performed that omitted the data from the first learning item.

In the present experiment, analyses were performed to see if serial position was related to the amount of arousal as assessed by the heart rate and blood volume methods. As may be seen in Figure 8, high arousal, as assessed by heart rate deceleration, was not associated with the first ordinal position. In addition, Ordinal Position One does not contribute unduly to the high-arousal category when the blood volume method of arousal assessment is under consideration (see Table 5). Since ordinal position was not consistently related to high arousal in either assessment method, no additional analyses omitting data from Item One will be considered.

Table 4. A Summary of Analysis of Variance on Total Recall Scores for Within Sources of Variance - BV

Source	*df*	*MS*	*F*	*p* <
(Arous)	1	.23	.13	.72
(Arous x OR)	2	2.52	1.48	.23
(Arous x Sex)	1	8.13	4.76	.03
(Arous x Retention)	1	10.07	5.90	.02
(Arous x Grade)	2	3.51	2.05	.13
(Arous x OR x Sex)	2	2.23	1.31	.27
(Arous x OR x Retention)	2	.54	.32	.73
(Arous x OR x Grade)	2	2.91	1.70	.15
(Arous x Sex x Retention)	1	.24	.14	.71
(Arous x Sex x Grade)	2	1.46	.86	.43
(Arous x Retention x Grade)	2	1.08	.63	.53
(Arous x OR x Sex x Retention)	2	1.00	59	.56
(Arous x OR x Sex x Grade)	4	1.81	1.06	.38
(Arous x OR x Retention x Grade)	4	1.10	.64	.63
(Arous x Sex x Retention x Grade)	2	1.03	.60	.55
(Arous x OR x Sex x Retention x Grade)	4	1.74	1.02	.40
Error	238	1.71		

Table 5. Number of Times Each Serial Position Produced a High or Low Blood Volume Arousal Reaction (N = 269)

Ordinal Position	High Arousal	Low Arousal
1	117	152
2	137	132
3	125	144
4	146	123
5	134	135
6	140	129
7	132	137
8	145	124

Tables 6 and 7 show the number of times each stimulus-response pair produced a high- or low-arousal reaction for the two arousal assessment methods. It may be seen that no particular word was contributing unduly to the high- or low-arousal category by either assessment method. In addition, no words were significantly different, multivariate $F(7, 255) = .88$, from each other in terms of the absolute heart rate deceleration values produced by the stimulus-response pairs (see Table 8, page 15). Thus, it appears that a particular stimulus-response pair had an equal probability of producing a high or low arousal reaction.

Table 6. Number of Times Each Stimulus-Response Pair Produced a High or Low Arousal Reaction Assessed by HR (N = 279)

Stimulus - Response Pair	High Arousal	Low Arousal
Pig - Wagon	134	145
Whistle - Fish	148	131
Lamp - Box	137	142
Telephone - Indian	134	145
Baby - Desk	137	142
Boat - Window	147	132
Flag - Wheel	142	137
Ball - Ladder	135	144

Table 7. Number of Times each Stimulus - Response Pair Produced a High or Low Arousal Reaction Assessed by Blood Volume (N = 270)

Stimulus - Response Pair	High Arousal	Low Arousal
Pig - Wagon	141	129
Whistle - Fish	134	136
Lamp - Box	122	148
Telephone - Indian	142	128
Baby - Desk	137	133
Boat - Window	137	133
Flag - Wheel	139	131
Ball - Ladder	126	144

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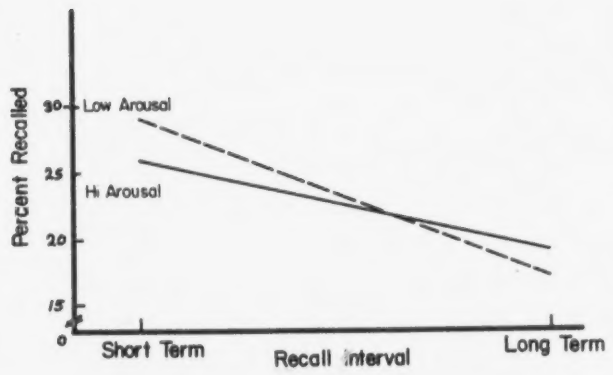

Figure 5. Differential Recall of High and Low Blood Volume Arousal Items at Short- and Long-Term Retention

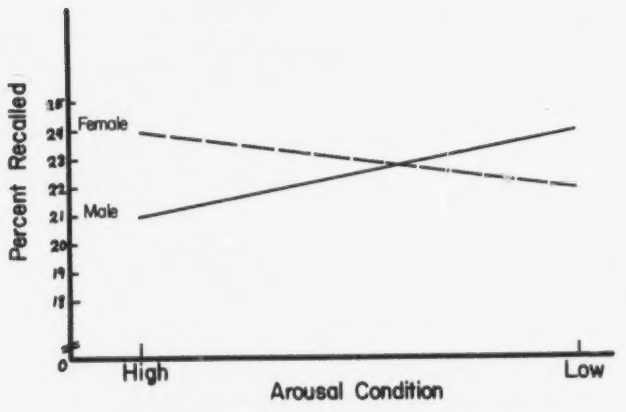

Figure 6. Differential Recall of High and Low Blood Volume Arousal Items as a Function of Sex

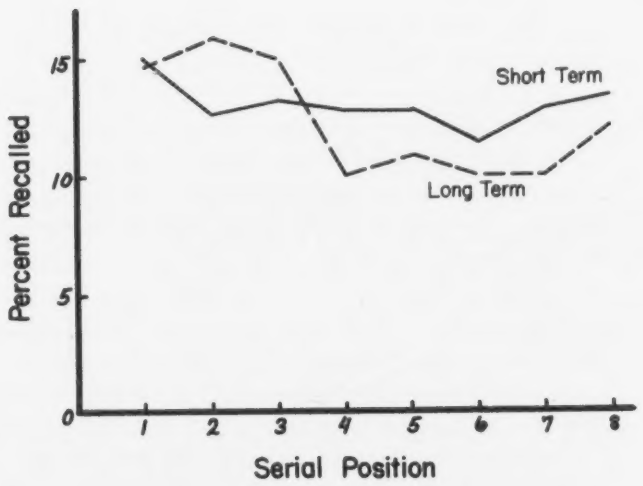

Figure 7. Per Cent Correct Short- and Long-Term Recall as a Function of Serial Position

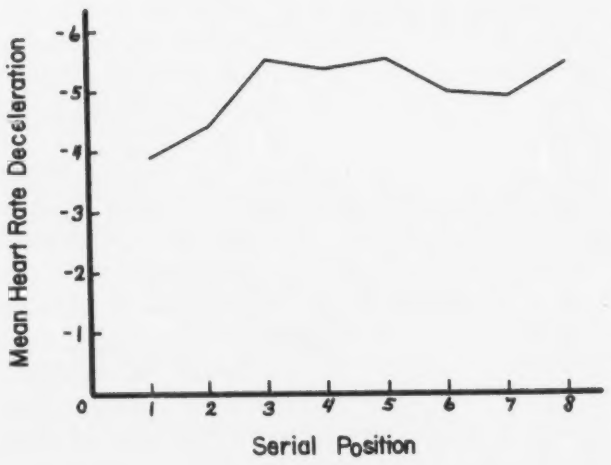

Figure 8. Mean Heart Rate Deceleration During Learning as a Function of Serial Position

Table 8. Absolute Arousal Value (HR) of Stimulus - Response Pairs (N = 279)

Stimulus - Response Pair	HR
Pig - Wagon	-4.73
Whistle - Fish	-5.54
Lamp - Box	-4.73
Telephone - Indian	-4.53
Baby - Desk	-4.90
Boat - Window	-4.46
Flag - Wheel	-5.16
Ball - Ladder	-4.82

IV
DISCUSSION

The results showing a significant cross-over interaction of arousal level (assessed by within -*S* vasoconstriction) and time of recall are similar to the findings of Kleinsmith and Kaplan (1963, 1964) and Walker and Tarte (1963) and that predicted by consolidation theory. The inhibiting effect of high arousal on short-term retention was confirmed in that recall for items learned under low arousal was superior to recall of items learned under high arousal.

Although the reverse was true at long-term retention, i.e., recall for items learned under high arousal was superior to recall of items under low arousal, the difference was not significant as in the Kleinsmith and Kaplan (1963, 1964) and Walker and Tarte (1963) studies when comparing the 24-hour retention groups. Furthermore, reminiscence for items learned under high arousal was not demonstrated in the present study.

The predicted interaction between time of recall and arousal level was not obtained when heart rate deceleration was used as the arousal assessment method, although the differences at short- and long-term retention were in the predicted direction. There are notable differences in methodology between the present study and the Kleinsmith and Kaplan (1963, 1964) and Walker and Tarte (1963) studies. First, their index of arousal was GSR deflection, whereas in the present study heart rate deceleration and digital vasoconstriction were used. Although all are peripheral measures of the autonomic nervous system, GSR is usually considered to be more sensitive to momentary changes. Both heart rate and vasomotor activity are subject to cyclic changes occurring in the absence of external stimulation. In addition, both the GSR and vasomotor responses are singly innervated by the sympathetic nervous system (Sternbach. 1966), whereas the heart rate response is dually innervated by the sympathetic and parasympathetic systems. Perhaps this could account for the fact that vasomotor assessment of arousal gave similar results to that of GRS assessment of arousal but heart rate did not.

The use of heart rate deceleration rather than acceleration for arousal assessment as indicated by Lacey's (1963) work on the directional fractionation of response could have been inappropriate. Since *S* was instructed to learn, which is in contrast to the Kleinsmith and Kaplan (1963, 1964) studies, he was not purely paying attention to the external environment, thus, not only "environmental intake" was taking place. Lacey (1963) found that the amount of heart rate change was at an intermediate value between acceleration and deceleration when *S* was given a task where he had to both pay attention to the external environment and mentally concentrate. Perhaps the range of response was decreased in the present study due to conflicting responses (environmental intake and environmental rejection), thus minimizing the differences between high- and low-arousal learning.

A second difference between the present study and the Kleinsmith and Kaplan (1963, 1964) and Walker and Tarte (1963) studies was the age of *S*s used, with children aged 5 through 10 used in the former and college-aged *S*s in the latter. Perhaps high arousal, although facilitating the strength of the permanent memory trace in both children and adults, has a more disruptive effect on children that does not wear off as soon as it does in adults. Several studies with adults (Lovejoy & Farley, 1969; Haveman & Farley, 1969) have not found high arousal to have a significant inhibiting effect on immediate recall, whereas the present study with children did. It is possible that this inhibiting effect hasn't

dissipated adequately in the 24-hour period and that a test of recall at a later period of a week would show larger differences in retention between items learned under high and low arousal. It was hoped that this age effect would result in an arousal by retention by grade interaction, but it did not appear. It is possible that the grade range was not great enough to show differences in the arousal and retention interaction as a function of age.

Grade level did enter into one interaction with arousal level (assessed by within -*S* heart rate response) and showed that with Kindergartners, who were the youngest age group studied, high arousal had a deleterious effect on retention when collapsed across both time intervals (see Fig. 4 on p. 13). This tends to support the previous explanation of the differences in long-term retention results between the present study and the Kleinsmith and Kaplan (1963, 1964) and Walker and Tarte (1963) studies on the basis of age. High arousal had a greater inhibiting effect on younger children and has not dissipated completely after 24 hours. This would imply that the dynamic trace period of the consolidation process continues for a greater time in younger children and that there is a greater interval between the short-term memory period and the structural trace period as proposed by Walker (1967). Second Grade *S*s showed better recall for items learned under high arousal when collapsed across both retention intervals, whereas Grade Four *S*s showed no differences in retention for items learned under high and low arousal. The Grade Two results are not consistent with the previous explanation but the fact is offered that Grade Two *S*s gave significantly lower ORs than those given by *S*s in either Kindergarten or Grade Four. The OR was also measured by heart rate response as was the arousal assessment method being presently discussed. Perhaps, Second Graders were in a lower arousal state, if OR can be used as a measure of activation, and any increase in arousal was facilitative at both short- and long-term retention due to the low initial arousal state.

It should be remembered that grade and arousal level when assessed by vasomotor response did not show a significant interaction. No explanation of this discrepancy can be offered except that the two systems were not necessarily predicted to be correlated because of previously mentioned differences in their operation.

High arousal learning, when assessed by vasomotor activity, facilitated retention for females but depressed retention for males. It is difficult to offer any explanation of this interaction between sex and arousal at this early age, especially since there was no overall sex difference in recall ability.

The complex interaction of OR level, sex, retention, and grade upon recall was not consistent with any predictions about the orienting response based on previous research results with adults or theoretical structure. Orienting response level can be used to predict recall only if *S*'s classification on grade, sex, and recall interval is taken into account. When the analysis is considered within each grade separately, it appears that the OR by sex by recall interval interaction exists only in Grade Two and Grade Four. Results across these two grades are inconsistent, e.g., High Orienting males show the best short-term retention in Grade Two but the poorest short-term retention in Grade Four. In Grade Two, Medium Orienting males demonstrate no forgetting in contrast with all other groups, whereas in Grade Four only Medium Orienting females demonstrate reminiscence. There seems to be no consistency in the results; one would hesitate to draw conclusions from this interaction.

Predicted arousal by OR interactions were not obtained when either heart rate or vasomotor data was considered.

Heart rate arousal tended to increase with advancing serial position in contrast to the GSR data of Farley and Lovejoy (1969) and Walker and Tarte (1963). This was also true of arousal assessed by vasomotor activity. In both cases, the item in Serial Position One was associated with the lowest degree of arousal as labeled by the experimenter. As was indicated earlier perhaps heart rate deceleration would not be considered high arousal but rather would be considered low arousal. If all one were doing was measuring the OR during learning, or attention to the stimuli, one would expect a greater orienting response to the first item due to subsequent habituation of response to later items. It has been shown that habituation occurs quite readily with non-signal stimuli, but in this case *S* was instructed to learn and consequently, stimuli should take on signal value. In this case, then, habituation might not be expected to occur.

The primacy effect in long-term retention is not accounted for by the relative heart rate or vasomotor arousal nor is the shape of the serial position curve at short-term retention associated with the arousal and serial position curve for either system.

The arousal by retention effects do not appear to be accounted for by associative qualities unique to a particular item since it appears that items have an equal probability of eliciting either a high or low arousal reaction (see Tables 6 and 7).

In sum, the data suggest that differential recall ability on a PA task can be predicted for children on the basis of a within -*S* assessment of arousal level during learning if vasomotor activity is used to estimate arousal. This prediction appears to be independent of age, sex, and OR level of the *S* and of associative properties of the stimuli and responses.

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